



EXERGAMING

Spielerisches Training für Körper und Geist

Prof. Dr. Anna Lisa Martin-Niedecken

Head of the Institute for Design Research
Department of Design
Zurich University of the Arts (ZHdK), CH

CEO & Founder, Sphery AG

Professor for esports, Sports Science, Health and Digital Innovation
Faculty of Sports Management
University of Applied Management (HAM), GER

36. Darmstädter Sport-Forum, 2023

2

Overview

- Technology x Sports: Extended Reality and Sports
- Gaming x Sports: Exergames
- How to: Exergame Design, Research and Implementation
- Conclusion



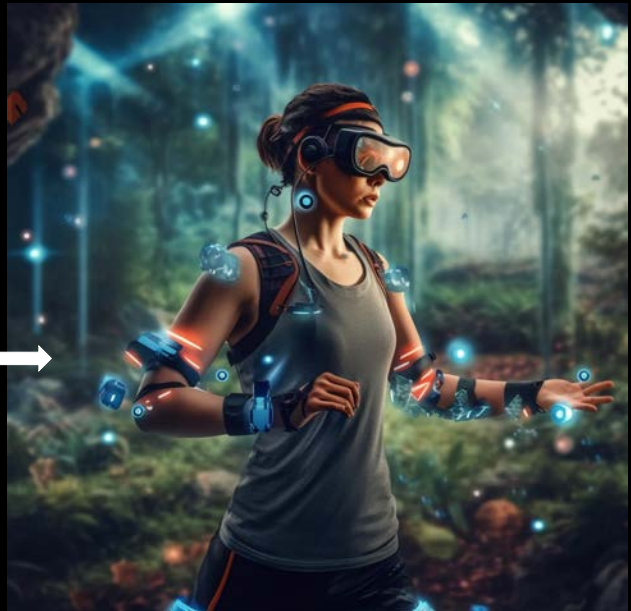
3

TECHNOLOGY x SPORTS

4



(iStockphoto)



(created with midjourney.com)

5

EXTENDED REALITY (XR)

Virtual Reality (VR) // Augmented Reality (AR) // Mixed Reality (MR)

6

EXTENDED REALITY



(Modified after: Milgram & Colquhoun, 1999)

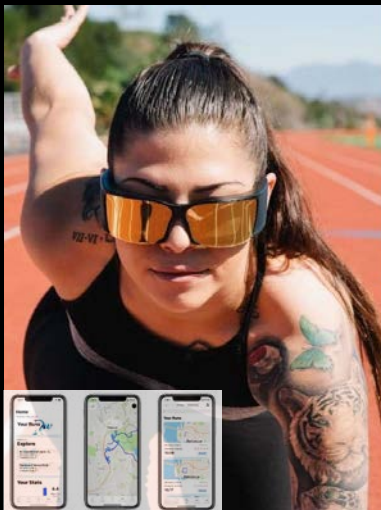
7

Augmented Reality Sports



Sports-Agility AR

Augmented Reality Sports



Ghost Pacer

Virtual Reality Sports



Tennis Esports

Mixed Reality Sports



Eon Sports

But...



Tenor.com

12

***SWEET SPOT
OF IMMERSION...***

13

DESIGN GUIDELINES...

- Focus on the **needs of users**.
- Make the technology **easy to use**.
- Allow for **personalization**.
- Ensure **safety and data protection**.
- Allow for **integration** with other technologies.
- Make the technology **accessible** to all users.
- Collaborate **across disciplines**.
- Provide **feedback and motivation**.

14

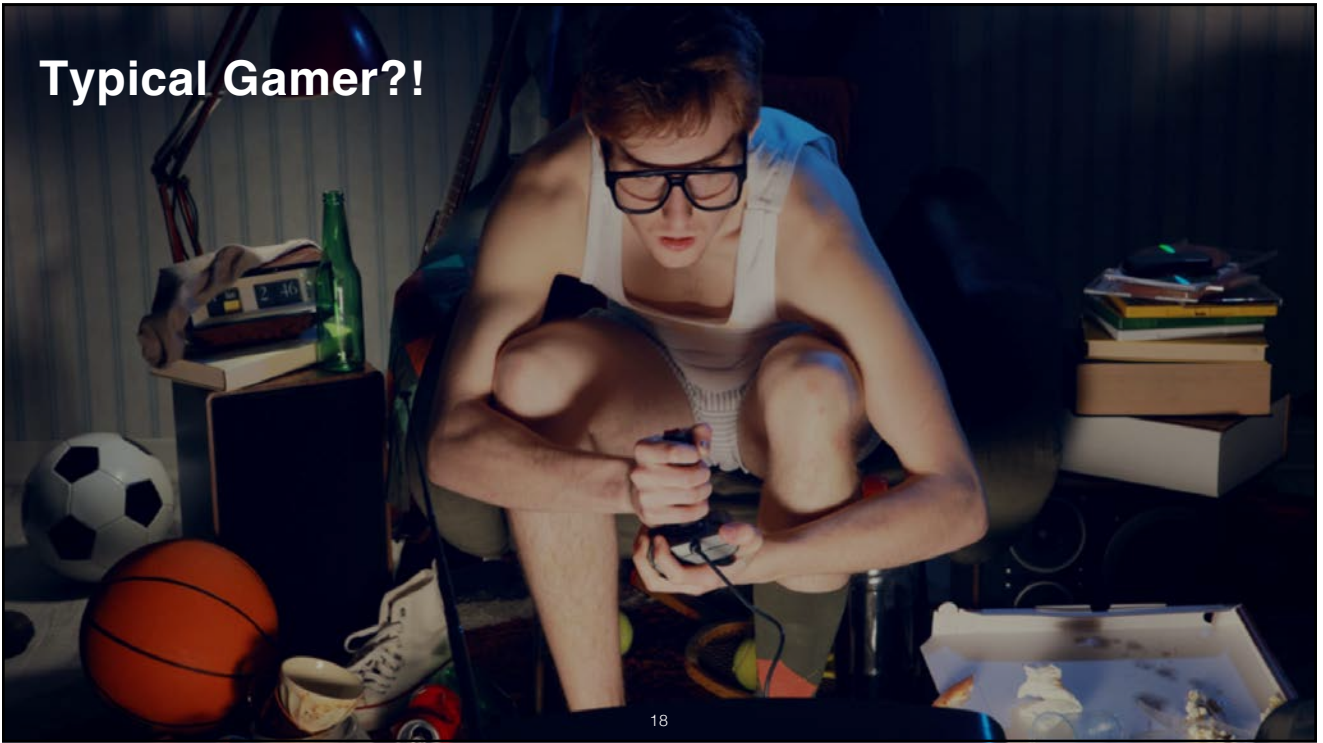
MOTIVATION...

15



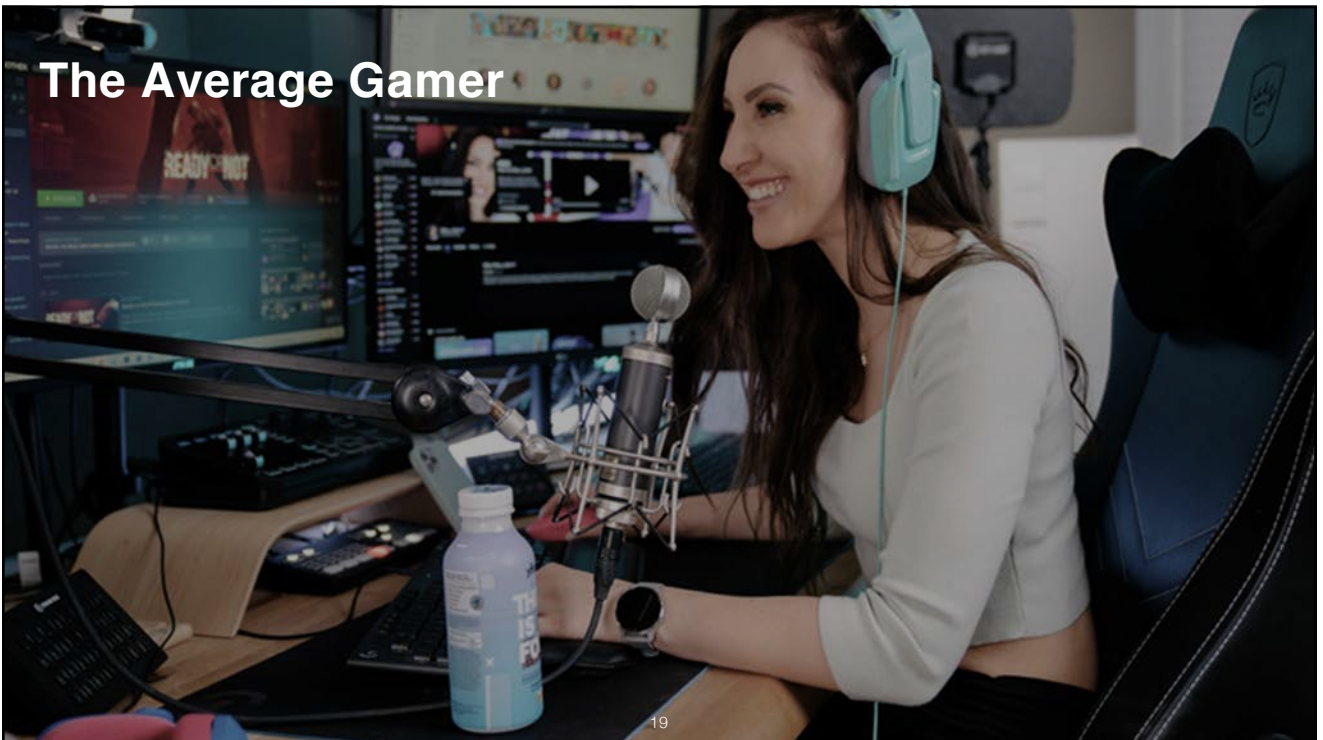
HOMO LUDENS?!

Typical Gamer?!



18

The Average Gamer



19

The Cognitive Athlete



Cognitive Athletes



GAMIFICATION

«The use of game-elements and game-design techniques in non-game contexts.»

(K. Werbach & D. Hunter)



THE HIGH SCORE
4500 50000

STAPLES

TOP 5 PLAYERS

SCORE	NAME	AGE	BLOOD
1	50000	GAPLUS	20 AB
2	50000	GAPLUS	21 O
3	50000	GAPLUS	22 B
4	50000	GAPLUS	23 A
5	50000	GAPLUS	24 AB

CREDIT 0

22

SERIOUS GAMES

«Games with a purpose beyond fun.»

(K. Werbach & D. Hunter)



DEEP VR



The Dragon Cancer



Re-Mission



Body Sleep

23

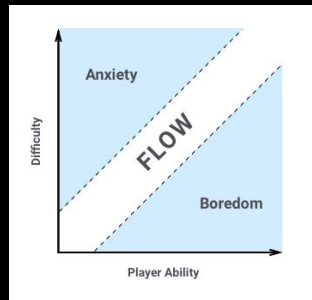
Gameplay Experience: Theories & Models

«Spiel ist eine freiwillige Handlung oder Beschäftigung, die innerhalb gewisser festgesetzter Grenzen von Zeit und Raum nach freiwillig angenommenen, aber unbedingt bindenden Regeln verrichtet wird, ihr Ziel in sich selber hat und begleitet wird von einem Gefühl der Spannung und Freude und dem Bewusstsein des *Andersseins* als das *gewöhnliche Leben*.»

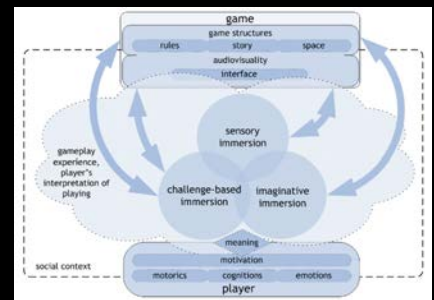
(Johan Huizinga, Homo Ludens – Vom Ursprung der Kultur im Spiel, 1938, S. 37)



(Bartle, 1996)



(Csikszentmihalyi, 1990)

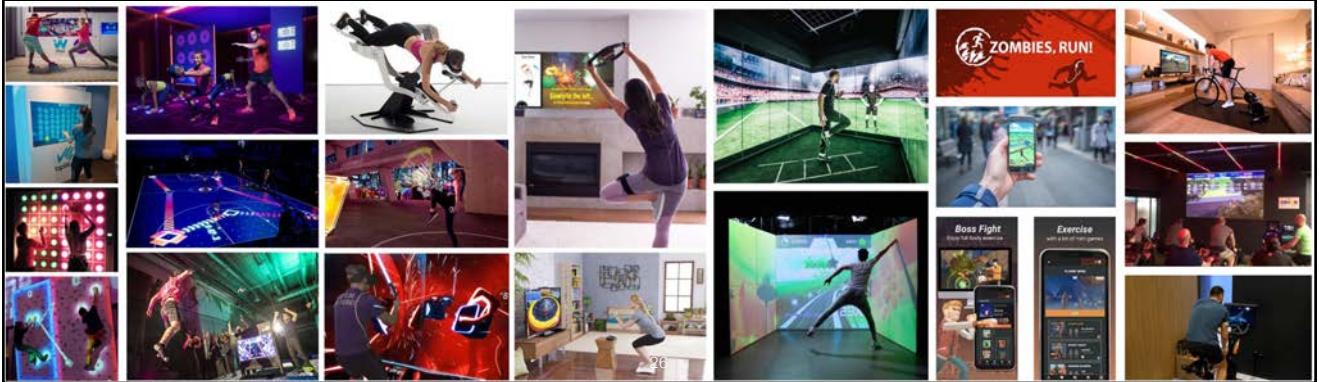


(Ermi & Mäyrä, 2005)

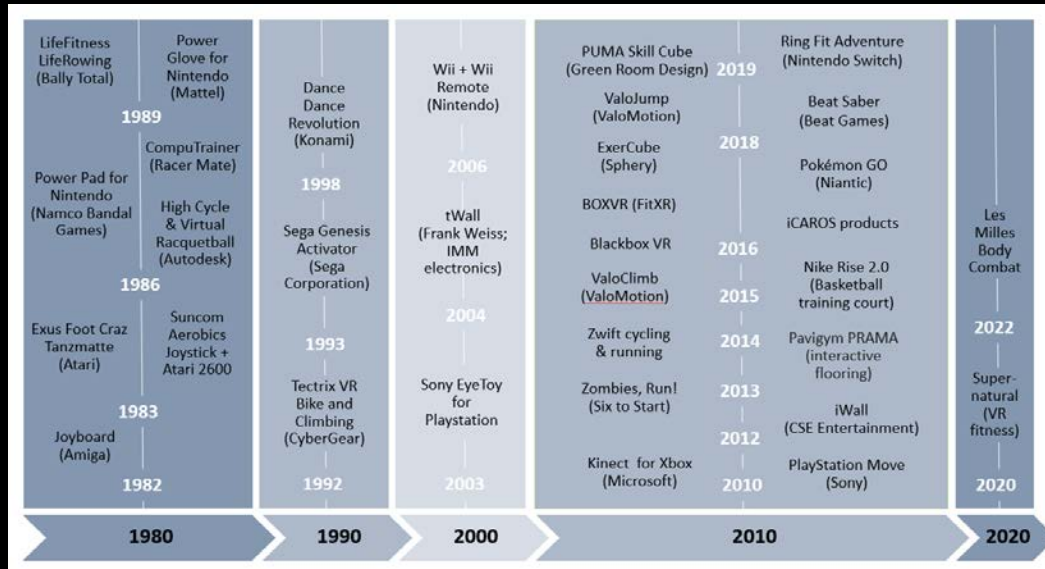
GAMING x SPORTS

EXERGAMES

(Exercise + Gaming)



Exergame History



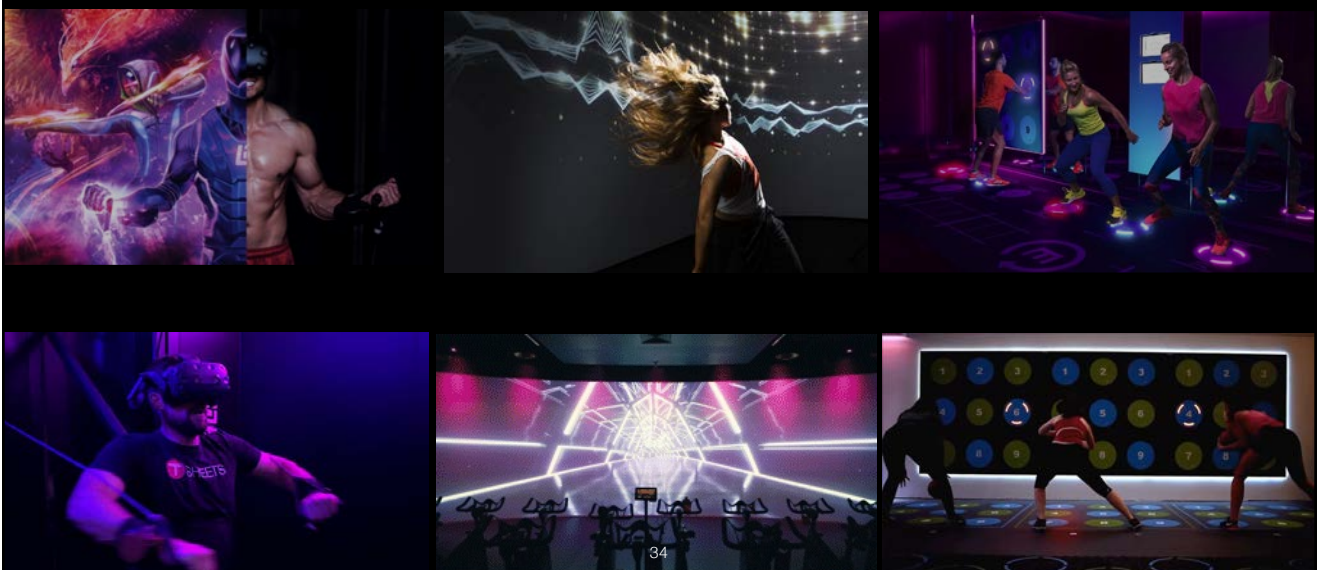
Exergames @home



Game-based Rehabilitation



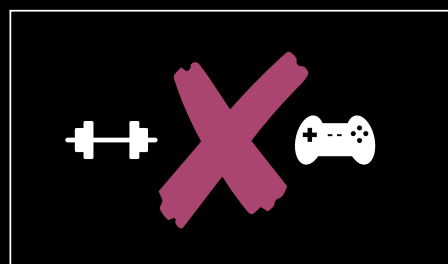
VR Fitness – Immersive Fitness – Gamified Fitness



FROM *SPORTIFICATION* OF GAMES TO *GAMIFICATION* OF SPORTS

49

What's missing?



50

Potential *EFFECTIVENESS* of Exergames

Perfect Timing!

PHYSICAL

COGNITIVE

MENTAL

EXECUTIVE FUNCTIONS

SELF-ESTEEM

PHYSICAL ACTIVITY

...

51

Potential *ATTRACTIVENESS* of Exergames

MOTIVATION

TRAINING ADHERENCE

EASY ACCESS

EMPOWERMENT

ENGAGEMENT

...

52



UNEXPLOITED Potential

LOW INTENSITY

***NO PHYSICAL-COGNITIVE
TRAINING***

NO SCIENTIFIC GROUNDING

NO INTERDISCIPLINARY R&D

NO USER INVOLVMENT

...

53

***HOW TO:
ATTRACTIVE & EFFECTIVE
EXERGAMES***

57

Project Overview



58

***INTERDISCIPLINARY,
USER-CENTERED,
RESEARCH-BASED &
ITERATIVE
DESIGN PROCESS***

59



SENSE EXPLORIA

R&D Projects (2018-2021) / supported by Innosuisse

63



Senso Exploria: User-centered Exergames for MS Patients

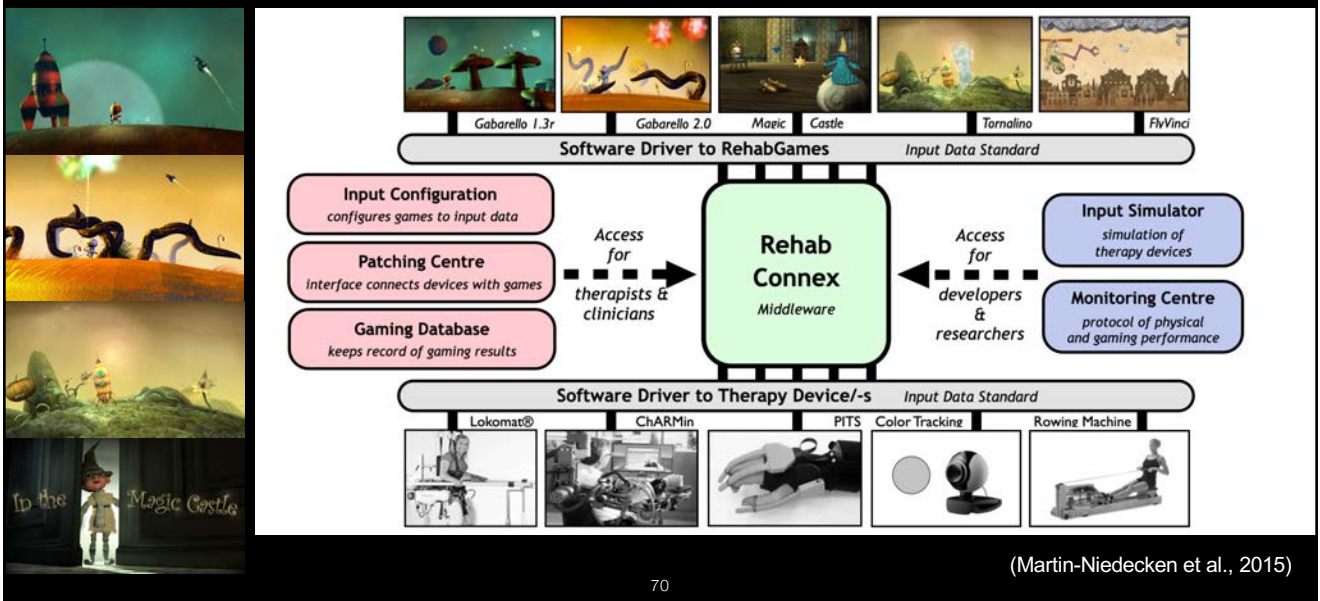
Dividat

(Schättin et al., 2021)

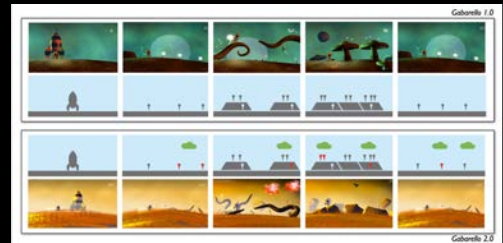
68



IMIC: Game-Based, Robot-Assisted Movement Therapy



IMIC: Player Experience Journey



(Martin-Niedecken et al., 2015)

71



72



IMPACT OF DIFFERENT DESIGN PARAMETERS

«Plunder Planet» & «The ExerCube»

**PLUNDER
PLANET**
AN ADAPTIVE EXERGAME ENVIRONMENT



76

MOVEMENT CONCEPT

77

Movement Concept



78

***AUDIO-VISUAL,
NARRATIVE DESIGN &
MECHANICS***

79

Game Scenarios & Mechanics



80

CONTROLLER

81

Controller

FULL-BODY-MOTION CONTI
FBMC



82

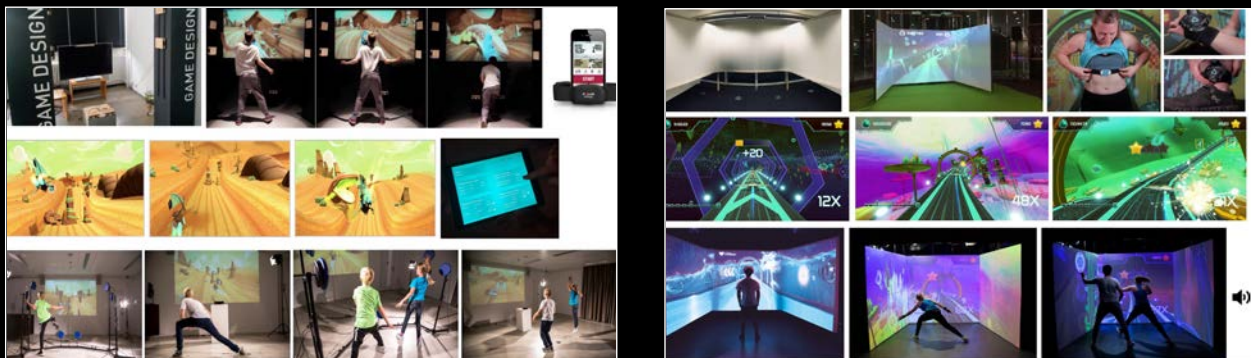
PLAYER MODE

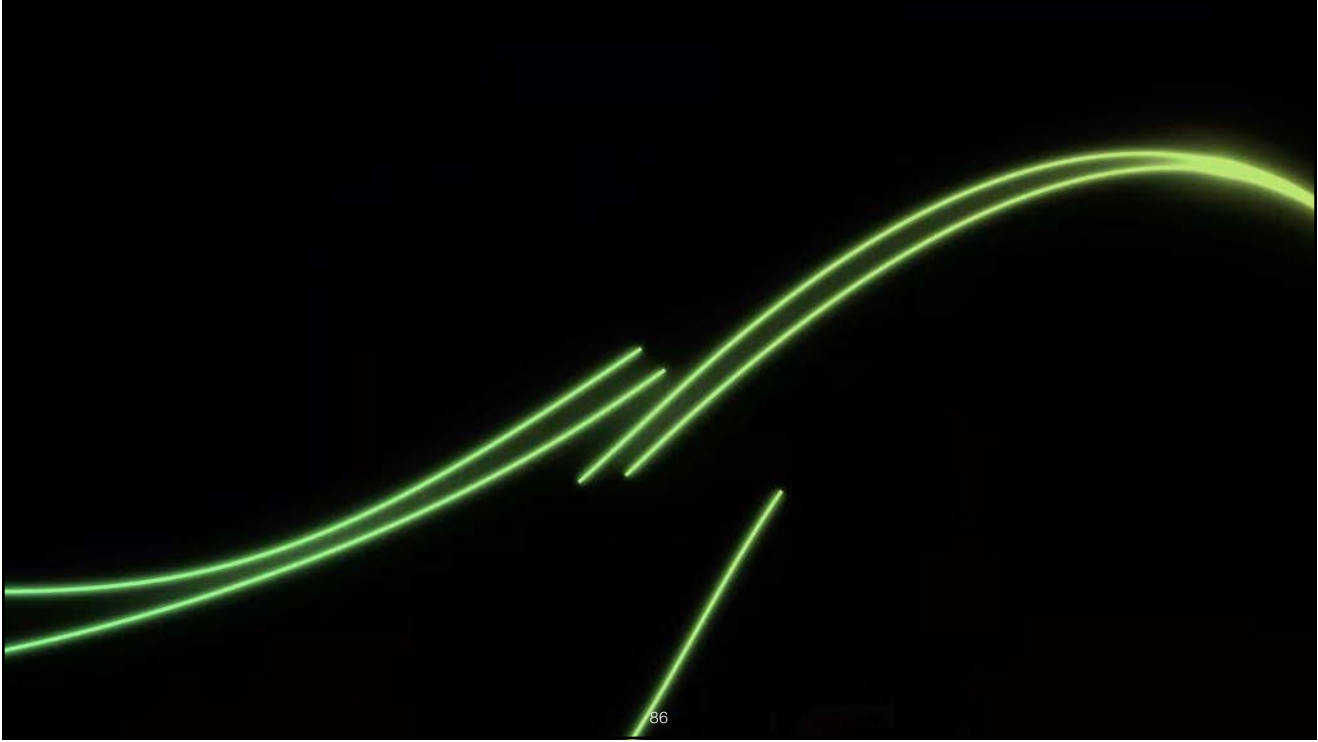
83

Player Mode



Research-Based, User-Centered Design Iterationen





International Research Network



EVALUATE & ADAPT

88

Impact of...

***CONTROLLER
FEATURES***

***MOVEMENT
CONCEPTS***

PLAYER MODES

***MOTOR-COGNITIVE
CHALLENGES***

***PLAYER-CENTRIC
ADAPTATION***

EMPOWERMENT

...

89

ExerCube vs. Personal Trainer



95

ExerCube vs. Personal Trainer – Subjective Experience

Difference: Mental Focus

The ExerCube:

Focus on game:

- "you're not explicitly conscious with your body [...] you're more driven by the game" -P9
- "my focus was definitely on collecting points" -P15

Focus on cognitive challenge:

- "it keeps challenging you [...] always have to think" -P1

Personal Training:

Focus on body & trainer:

- "was able to focus more on the body" -P20
- "more focused on the movement pattern" -P4

Difference: Perception of Exertion

The ExerCube:

Delayed awareness of physical exertion:

- "I noticed the physical exertion afterwards, but never during" -P23
- "had to physically perform, but didn't notice it at all during, what I noticed is— afterwards when I exited—I was sweating" -P28

Personal Training:

Permanent awareness of physical exertion:

- "I noticed the physical exertion during the whole session. My muscles were burning and my heart was beating fast." -P23

PT:

- Player's focus more on own body
- Stronger physical exertion
- Social pressure

Difference: Social Factors

The ExerCube:

No fear of mistakes:

- "less issues having failures in a game" -P17

Personal Training:

More personal:

- "feeling secure [...] accompanied one-to-one" -P9 ; "more personal" -P18

More pressure:

- "I felt stressed [...] scared that I do it wrong [...] with a human in front of you it's more important what he thinks of me" -P26

ExerCube:

- Less physical exertion
- Stronger cognitive exertion
- «feel free»

96

(Martin-Niedecken et al. 2019)

Comparison of Effectiveness

	ExerCube	Traditional fHIIT	z	p	r
Average HR [bpm]	155.0 [141.5; 161.3]	159.5 [150.3; 167.0]	-2.878	.003*	0.46
Average HR (% of calculated HR _{max})	78.7 [72.6; 82.2]	81.1 [77.9; 85.8]	-2.837	.005*	0.45
Maximal HR [bpm]	182.5 [172.0; 191.0]	180.5 [176.0; 190.8]	-0.262	.806	0.04
Maximal HR (% of calculated HR _{max})	93.0 [88.7; 97.4]	91.6 [93.6; 97.3]	-0.302	.388	0.05
	ExerCube	Traditional fHIIT	z	p	r
Borg _{physical}	7.0 [6.0; 8.0]	9.0 [8.0; 9.0]	-3.020	.001*	0.48
Borg _{cognitive}	6.5 [5.0; 8.0]	5.0 [4.0; 6.0]	-1.603	.113	0.25

*=p<.05=significant

ExerCube:

- slightly lower physical exertion BUT average heart rate reached the functional HIIT threshold
- subjectively experienced higher cognitive load (dual-domain training)

(Martin-Niedecken et al. 2020)

97

Comparison of Attractiveness

Questionnaires		ExerCube	Traditional fHIIT	z	p	r
SIMS	intrinsic motivation	6.5 [5.8; 6.8]	5.1 [4.5; 5.5]	-3.566	<.001*	0.56
	identified regulation	6.3 [5.5; 6.7]	6.0 [5.6; 6.7]	-0.029	>.999	0.01
	external regulation	1.3 [1.0; 2.4]	1.6 [1.3; 2.7]	-0.940	.367	0.15
	amotivation	1.0 [1.0; 1.6]	1.3 [1.0; 1.9]	-0.939	.388	0.15
FSS	overall	6.0 [5.6; 6.4]	5.4 [4.9; 5.8]	-3.663	<.001*	0.58
	fluency of performance	6.3 [5.5; 6.5]	5.7 [5.2; 6.4]	-1.708	.088	0.27
	absorption by activity	6.0 [5.5; 6.5]	4.9 [4.5; 5.8]	-3.436	.001*	0.54
	perceived importance	1.7 [1.0; 2.2]	1.0 [1.0; 1.8]	-2.519	.012*	0.40
PACES		6.3 [6.0; 6.6]	5.0 [4.7; 5.5]	-3.884	<.001*	0.61

*=p<.05=significant

- ExerCube: sig. better results for flow, enjoyment & motivation

(Martin-Niedecken et al. 2020)

98

Embodied Sketching – Multiplayer Makeover



- Differentially balanced experiences of social immersion, fun & physical and cognitive exertion
- Identification of promising new player formations

99

(Martin-Niedecken et al., 2019)

EVALUATE

100

Investigation of

**COGNITIVE(-MOTOR)
FUNCTIONS**

**ANTROPOMETRIC
PARAMETERS**

PHYSICAL FITNESS

**EXECUTIVE
FUNCTIONS**

...

101

ExerCube Training in Young Athletes



AIM: Gathering insights into the training effects of the ExerCube on **cognitive(-motor) functions** in young game athletes.

102

Results – Non-Randomized Controlled Trial

- 24 young game sports athletes (15 ± 0.7 years; 46% girls)
- 10 weeks intervention time → shortened to 8 weeks (due to pandemic restrictions):
 - Intervention group: 2x 25min ExerCube training per week + sports-specific training
 - Control group: Sports-specific training only
- Sig. positive effects on **cognitive (motor) skills** (faster reaction times), especially on **concentration** ($U=-2.483$, $p=0.013$, $r=0.51$), **cognitive flexibility** ($F=12.176$, $p<0.001$, $d=1.488$), and **divided attention** ($F=9.776$, $p=0.002$, $d=1.404$).

103

(Martin-Niedecken et al., 2023)

ExerCube @School



AIM: Investigation of effects of a school-based exergame intervention on **anthropometric parameters** and **physical fitness**

104

Results – Randomized Controlled Trial

- 58 students (10.4 ± 0.8 years; 48% girls) → only 34 students included in final analysis (due to pandemic restrictions)
- 3 month intervention time:
 - Intervention group: 2x 20min ExerCube training per week + physical education classes
 - Control group: Physical education classes only

Outcome	IG (n = 18)		CG (n = 16)		p-Values	η ²
	Pre	Post	Pre	Post		
BMI (kg·m ⁻²)	21.7 ± 4.0	21.6 ± 4.2	19.3 ± 4.1	19.7 ± 4.1	n.s.	0.063
WHtR	0.47 ± 0.05	0.46 ± 0.05	0.44 ± 0.07	0.45 ± 0.07	n.s.	0.114
CMJ (cm)	18.6 ± 5.4	21.1 ± 5.2 ***	20.5 ± 5.2	18.6 ± 3.6 **	<0.001	0.403
ST (s)	4.12 ± 0.45	4.08 ± 0.47	4.06 ± 0.35	4.18 ± 0.32	0.020	0.157
SRT (m)	450.0 ± 228.0	537.8 ± 210.5 *	498.7 ± 208.3	469.3 ± 162.3	0.046	0.122

Abbreviations: Pre—before intervention; post—after intervention; BMI—body mass index; WHtR—waist-to-height ratio; CMJ—countermovement jump; ST—sprint test; SRT—shuttle run test; η²—partial eta squared. * p < 0.05, ** p < 0.01, and *** p < 0.001 represent changes from before to after intervention for the IG and CG. p-values represent interaction effects.

CMJ = Counter movement jumps → sig. increase in IG
 SRT = Shuttle run test → sig. increase in IG
 ST = Sprint test → sig. increase in IG

WHtR = Waist to height ratio
 BMI = Body mass index

(Ketelhut et al., 2022)

EXTEND

ExerG: Exergame-based Geriatric Therapy



AIM: Adaptation of user-centered soft- and hardware design for the geriatric movement therapy and investigation of acute, and long-term effects on motor-cognitive functions (with relation to every day activities).

107

AAL Project

108

ExerCube @Home: On-Body Game Elements

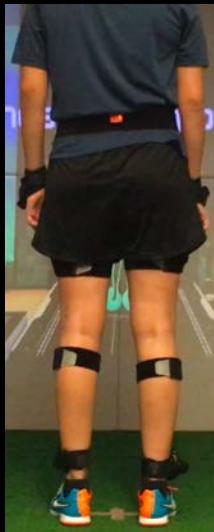


AIM: Exploration of new physically immersive feedback designs for an @home exergame and investigation of long-term physical and cognitive effects and motivation of a training intervention @home.

109

Innosuisse Project

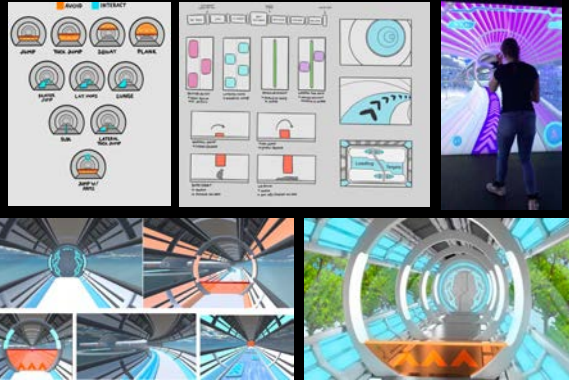
ExerUp: Exergame-based Sports Rehabilitation



113

DIZH Project

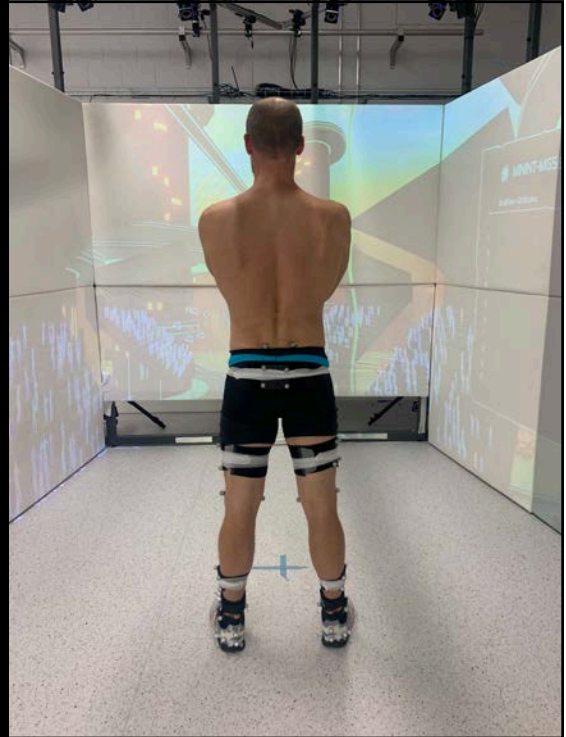
«Control to Chaos»



Foci:

- Phase 3 of therapy after knee injury
- Return to sports (control to chaos)

114



115

The Emotional Journey of Exergames



Further Studies with the ExerCube

Journal of Clinical Medicine | MDPI

Article

Integrating Regular Exergaming Sessions in the ExerCube into a School Setting Increases Physical Fitness in Elementary School Children: A Randomized Controlled Trial

Sascha Ketelhut ^{1,*}, Lisa Röglin ², Anna Lisa Martin-Niedecken ³, Claudio R. Nigg ⁴ and Kerstin Ketelhut ⁴

Games FOR HEALTH JOURNAL: Research, Development, and Clinical Applications | Volume 11, Number 1, 2022 | © Mary Ann Liebert, Inc. | DOI: 10.1089/g4m.2021.0166

Original Article

Acute Effects of Heart Rate-Controlled Exergaming on Vascular Function in Young Adults

Eva Kircher, MA¹, Sascha Ketelhut, PhD^{2*}, Kerstin Ketelhut, PhD³, Lisa Röglin, MEd⁴, Anna Lisa Martin-Niedecken, PhD⁵, Kuno Hottenrott, PhD⁶ and Reinhard G. Ketelhut, PhD, MD⁷

International Journal of Environmental Research and Public Health | MDPI

Article

A Game-Based Approach to Lower Blood Pressure? Comparing Acute Hemodynamic Responses to Endurance Exercise and Exergaming: A Randomized Crossover Trial

Eva Kircher ¹, Sascha Ketelhut ^{2,*}, Kerstin Ketelhut ³, Lisa Röglin ², Kuno Hottenrott ², Anna Lisa Martin-Niedecken ⁴ and Reinhard G. Ketelhut ^{1,5}

Frontiers in Cardiovascular Medicine | Volume 9, Article 822022 | DOI: 10.3389/fcvm.2022.822022

Original Article

Gaming Instead of Training? Exergaming Induces High-Intensity Exercise Stimulus and Reduces Cardiovascular Reactivity to Cold Pressor Test

Sascha Ketelhut^{1*}, Reinhard G. Ketelhut¹, Eva Kircher¹, Lisa Röglin², Kuno Hottenrott², Anna Lisa Martin-Niedecken⁴ and Kerstin Ketelhut³

Frontiers in Psychology | Volume 13, Article 902222 | DOI: 10.3389/fpsyg.2022.902222

Original Article

The New Way to Exercise? Evaluating an Innovative Heart-rate-controlled Exergame

Authors: Sascha Ketelhut¹, Lisa Röglin², Eva Kircher², Anna Lisa Martin-Niedecken³, Reinhard Ketelhut^{2,5}, Kuno Hottenrott¹, Kerstin Ketelhut¹

frontiers | Volume 13, Article 902222 | DOI: 10.3389/fpsyg.2022.902222

Original Article

Adaptive High-Intensity Exergaming: The More Enjoyable Alternative to Conventional Training Approaches Despite Working Harder

Lisa Röglin, MA¹, Sascha Ketelhut, PhD^{2*}, Kerstin Ketelhut, PhD³, Eva Kircher, MA⁴, Reinhard G. Ketelhut, PhD, MD^{1,5}, Anna Lisa Martin-Niedecken, PhD⁶, Kuno Hottenrott, PhD⁷, and Oliver Stoll, PhD⁸

frontiers | Volume 13, Article 902222 | DOI: 10.3389/fpsyg.2022.902222

Original Article

Impact of an Exergame Intervention on Cognitive-Motor Functions and Training Experience in Young Team Sports Athletes: A Non-Randomized Controlled Trial

Anna L. Martin-Niedecken^{1,2*}, Kerstin Bucher³, Marlene Adonis⁴, Eling B. de Bruin^{5,6,7}, Alexandra Sauer^{8,9}

FROM THE LAB TO THE FIELD

118

Application Areas



119



Game Selection – Foci

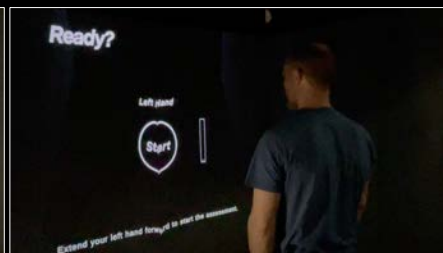


122

Motor-Cognitive Assessments



Trail Making



Simple Reaction



N Back

123

8-Weeks Training Plan

David Habluetzel



CONCLUSION

INNOVATION



MOTIVATION

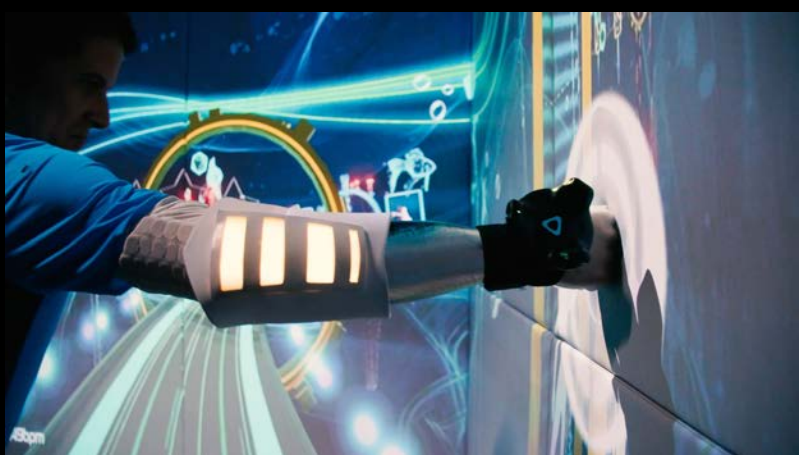


INCLUSION



129

EMPOWERMENT

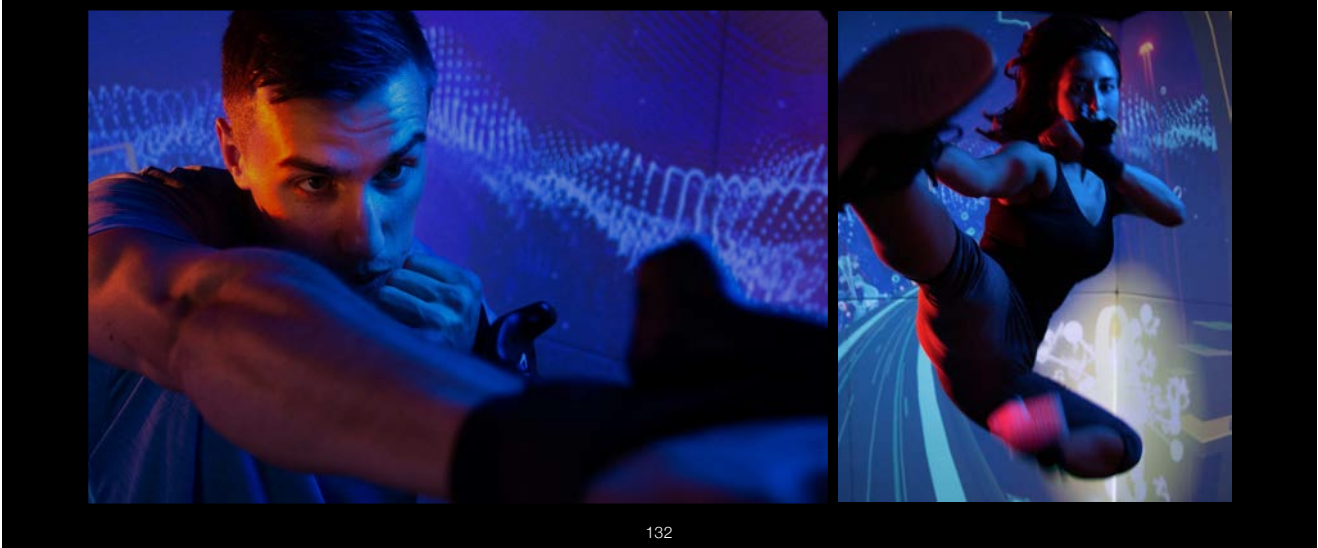


130

CUSTOMIZATION



TRAINING BENEFITS



EMOTIONS



133

THANK YOU!

Prof. Dr. Anna Lisa Martin-Niedecken

Head of the Institute for Design Research
Department of Design
Zurich University of the Arts (ZHdK), CH

CEO & Founder, Sphery AG

Professor for esports, Sports Science, Health and Digital Innovation
Faculty of Sports Management
University of Applied Management (HAM), GER

136